Guide to Safety in Utility Integration of Energy Storage Systems

Presented by David Rosewater

On the behalf of:

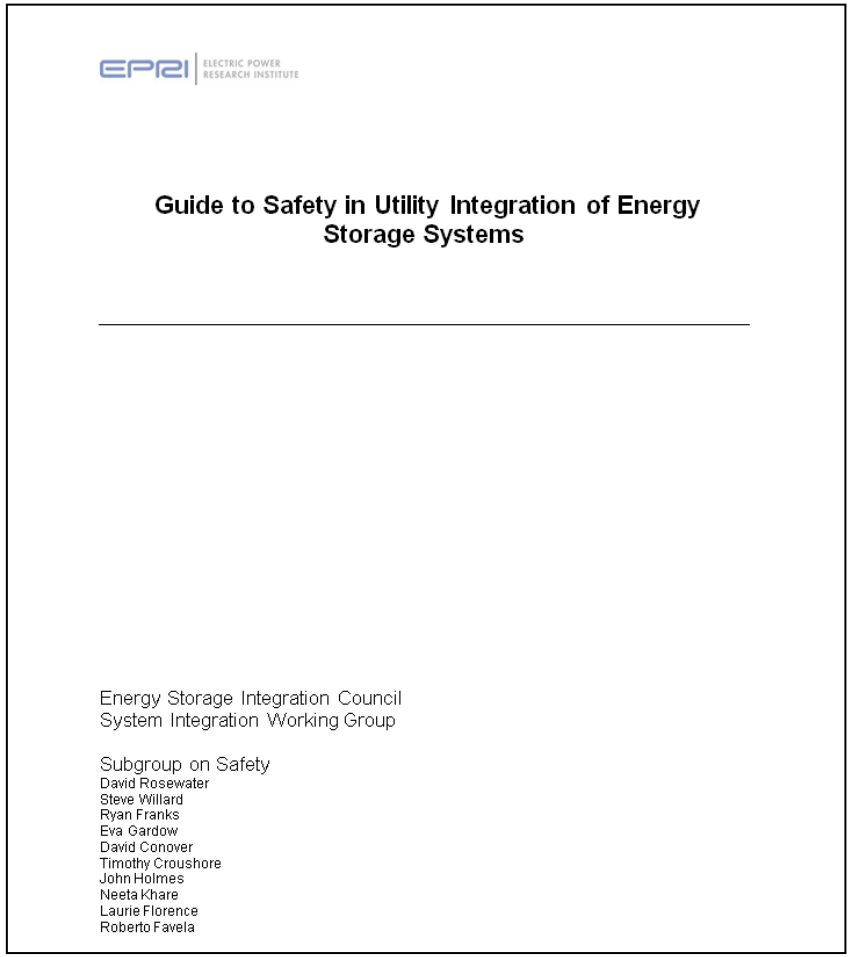
Energy Storage Integration Council (ESIC)

Subgroup on Safety

Overarching Structure

- Two similar but different groups
- Energy Storage Integration Council (ESIC)
  - EPRI formed and lead
  - Subgroup on Safety
  - Developed guidance on safe integration of ESS
- Energy Storage Safety Working Group (ESSWG)
  - DOE formed and lead
  - Subgroup on Safety Outreach and Incident Response
  - Working now to help make guidance available to stakeholder groups

Outline for “Guide to Safety in Utility Integration of Energy Storage Systems”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Guide to Safety in Utility Integration of Energy Storage Systems

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ABSTRACT

- Safety is critical to successful procurement of energy storage. Yet, safety aspects can be difficult to assess and it is easy to overlook at many stages in the integration process. To address these issues for distribution utilities, the Energy Storage Integration Council (ESIC) tasked the system integration working group to develop guidance for managing safety throughout the integration process. This document introduces some of the challenges to safety when procuring energy storage, presents the results of a gaps analysis for safety in the integration process, and then provides guidance on managing safety throughout the project lifecycle. Detailed information is provided in the appendix on unique considerations at each stage of the process and lists several potentially relevant standards.

Identified Gaps

- Science-based safety validation techniques
- Incident preparedness
- Safety documentation (general CSRs)
- Lack of guidance for analyses of safety requirements during project inception
- Lack of standard energy storage products and options to choose from
- Regulators, inspectors and other AHJs are unfamiliar with energy storage
- Lack of protocols to be able to pre-validate the safety of designs and design options
- The numerous and immature CSRs for distribution connected storage
- The lack of an independent arbiter on safety for AHJs to rely on

SAFETY GUIDANCE

THE Integration Process By Codes, Standards, And Regulations

- It is intended that these documents would be referenced as appropriate with the above materials in preparing the specifications and other documents necessary to implement the planning, design, construction, installation, commissioning, operations, maintenance and decommissioning of the ESS as well as providing for safety of personnel and property during those activities and responding to incidents that may occur that are attributable to or could affect the system. Figure 4-1 shows the structure of this Chapter as organized by functional area.

Quick Reference For Recommended Documents

Safety Package Document List	Developed by	Reviewed by	Details of What to Include
Documentation of need for ESS	Utility Procurement	Utility Management	Section 3.1
Documentation of early stage safety considerations	Utility Procurement	Utility Management	Section 3.1
Procurement specification and project scope	Utility Procurement	Utility Management	Sections 3.2 and 4
Applicable standards and compliance package	ESS Provider	Utility and/or Third Party	Section 4
Failure Modes and Effects Analysis (FMEA)	ESS Provider	Utility and/or Third Party	Section 3.2.1
System Safety Analysis (SSA)	ESS Provider	Utility and/or Third Party	Section 3.2.2
Commissioning plan	ESS Provider	Utility and/or Third Party	Sections 3.3 and 4.4
Qualification program to train operation and maintenance personnel	ESS Provider	Utility and/or Third Party	Sections 3.2.3 and 4.6
Operation and maintenance manual	ESS Provider	Utility and/or Third Party	Sections 3.4 and 4.5
Incident training manual	ESS Provider	Utility, Third Party, and Other Stakeholders	Sections 3.2.3 and 4.6
Emergency action plan	ESS Provider	Utility, Third Party, and Other Stakeholders	Sections 3.2.3 and 4.6
Decommissioning, disposal and recycling plan	ESS Provider	Utility and/or Third Party	Section 3.4

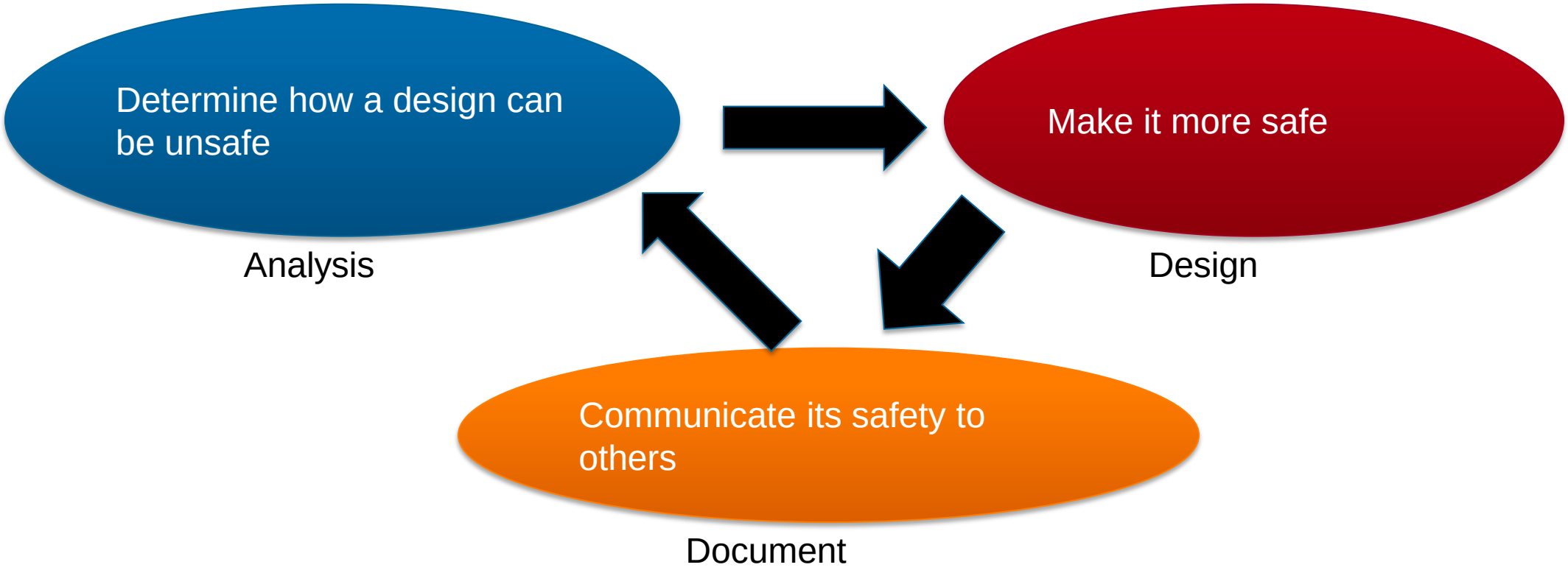
Example of Documentation: Failure Modes and Effects Analysis (FMEA)

Goals: Start the conversation on safety, generate a quick list of what can go wrong and why, prioritize that list for what to work on first.

System or Component	Failure Mode	Hazard Effect	Consequence	Prevent	Detect	Probability, Severity	Expected Value for Risk
BMS	system doesn't operate safely through normally expected temperature operating range	Fire	safety incident	BMS testing	independent temperature sensor	3,10	30
Battery Cell	group of failures	Fire	safety incident	abuse testing	fire alarm	3,9	27
Battery Pack	group of failures	Fire	safety incident	abuse testing	fire alarm	2,10	20
BMS	Battery damage due to BMS malfunction	Fire or loss of function	safety incident	fusing, inverter protection		2,7	14
Inverter	Inverter fails to detect/react to over temperature IGBTs	Loss of function	Power output de-rating	rely on supplier		3,4	12

System Safety Analysis (SSA)

Goals: Understand the uncertainty about what could happen, analyze how accidents could happen, change the design to prevent accidents, communicate safety and inform decision making

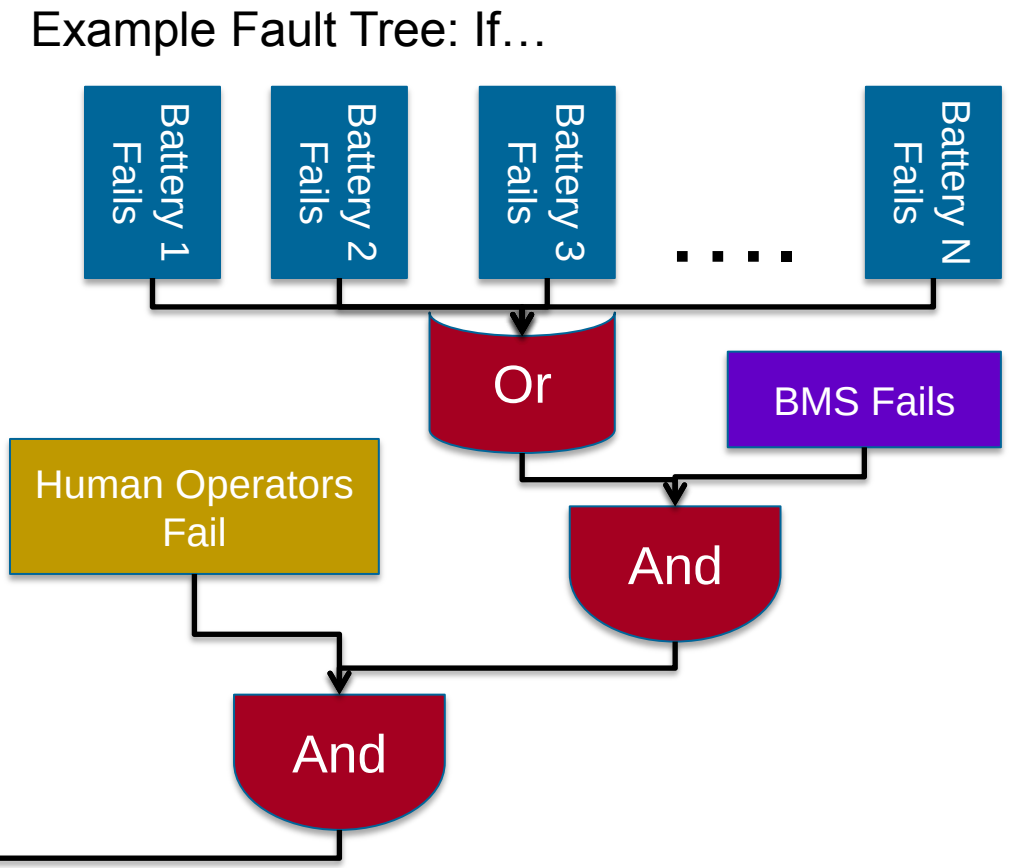


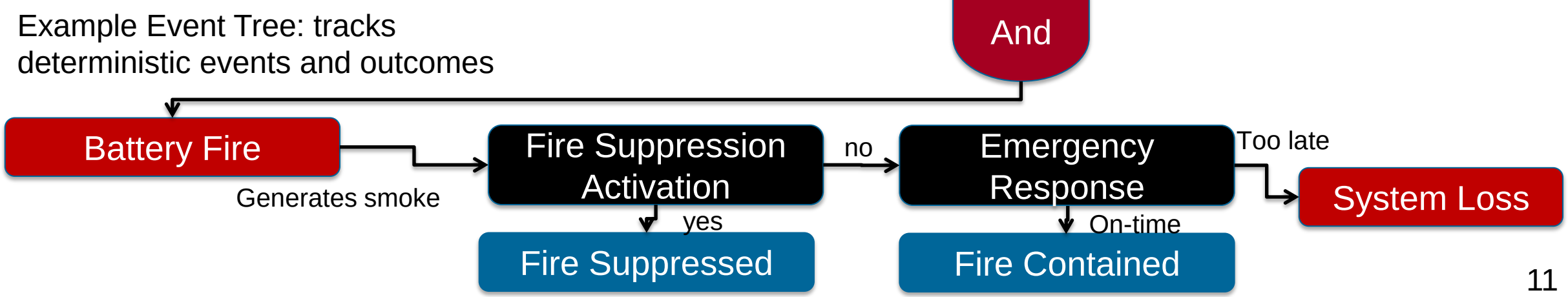
Probability Risk Assessment (PRA)

Analysis answers three questions:

1. **What** can go wrong?
2. How **likely** is that?
3. How **bad** would that be?

PRA Consists of a combination of Event trees and Fault trees





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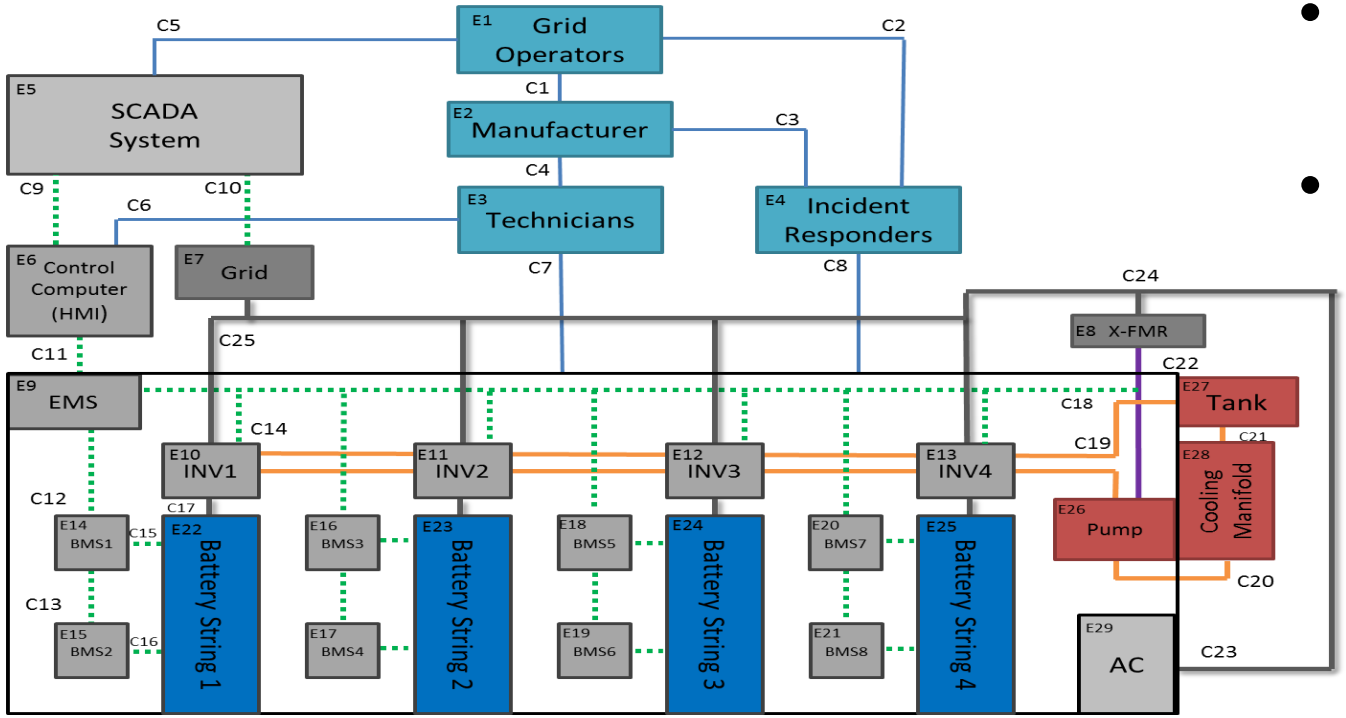
System-Theoretic Process Analysis (STPA)

- Accidents occur when interactions violate **safety constraints**,
- The system enforces these constraints using **control**.



Defining System Losses and Hazardous States

- STPA Step 1 Find **Unsafe Control Actions**
- STPA Step 2 Determine **Causal Factors**

Final Thoughts

- Energy Storage Integration Council has Developed a Guide to Safety in Utility Integration of Energy Storage Systems
- Energy Stooge Safety Working Group (ESSWG) Outreach and Incident Response Subgroup is Leveraging this work by developing templates for:
  - Applicable standards and compliance package
  - Failure Modes and Effects Analysis (FMEA)
  - System Safety Analysis (SSA)
  - Commissioning plan
  - Qualification program to train operation and maintenance personnel
  - Operation and maintenance manual
  - Incident training manual
  - Emergency action plan

Questions

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